

Intermediate Data Record Support for the Viking Prime Mission

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In producing Intermediate Data Records (IDRs) to satisfy the demanding requirements of the Viking Prime Mission, the DSN was called upon to make many procedural, hardware, and software workarounds to compensate for the deficiencies that inevitably come to light when a complex new capability such as the Network Data Processing Area is exposed to a high-demand operational environment for the first time. In due course, most of the problems were identified and corrected, or modifications were made to the IDR system design. Despite these difficulties, IDR production for the Viking Prime Mission achieved an astonishing level of performance both in quantity of data delivered and timelines of delivery. This article discusses the more significant problems encountered in IDR production during the mission and gives a definitive statement of the production levels accomplished.

I. Introduction

The DSN has met the telemetry Intermediate Data Records (IDR) commitment to the Viking Project Prime Mission. As with any new system, there were numerous anomalies which had an adverse impact on accomplishment of that task. Experience with the Data Records Processor (DRP), coupled with improvements to the hardware and software and the development of more efficient operational strategies to cope with many of the problems, led to a maximization of data percentages delivered and minimized generation/delivery times.

Generation of IDRs is the prime task of the Network Data Processing Terminal (NDPT) located in Building 230 (Fig. 1). The DRP software is used for the recall and merge functions,

while the Network Log Processor (NLP) records all data on Network Data Log tapes.

This report presents an analysis of the NDPT's performance in the accomplishment of that commitment from 19 April through 10 November 1976. Included are all orbital IDRs containing lander direct and relay data, as well as the remake and supplemental IDR requests received from Viking Project Data Records personnel. Each IDR includes tapes and summaries required for each unique station pass.

Following the performance analysis is a discussion of the constraints and problems that were encountered, and the corrective actions taken to cope with those problems. Additionally, the planned enhancements to the system are discussed.

II. Performance

The percentage of telemetry Intermediate Data Record data delivered to the Viking Project averaged 99.988 percent of the committed data from the stations' Digital Original Data Record magnetic tapes. The majority of the missing data were delivered at a later date. Delivery times ranged from less than 1 h to several days from the end of each station pass.¹

Figure 2 depicts the weekly data percentages delivered over the 28 weeks covered by this report. The first 14 weeks show an erratic pattern of accomplishment, while the last 14 weeks' output was basically stable. This improvement was due to the development of new operational techniques to handle magnetic tape "read" problems and two key milestone events. On 6 June, a new Data Records Processor software package, with a new magnetic tape handler, was incorporated into the system. Unfortunately, this new handler had been written for a slightly different hardware package. An investigation by NDPT personnel uncovered the needed changes and, on July 27, a modification to the DRP's tape controller was implemented. From that point on, the data percentage stabilized and the generation times decreased.

Prior to Orbital Operations, the merge/Intermediate Data Records work load was sporadic, as was the output. Starting with 21 June, through 3 November, around-the-clock coverage became mandatory. There were 782 Intermediate Data Records delivered, with an additional 102 Remake/Supplemental IDR Requests completed (Table 1). An average of 99.990 percent of the required data were delivered within 9.07 h of the scheduled station loss-of-signal at the 64-m stations. Of this total, 46 IDRs were delivered more than 24 h after Loss of Signal (LOS). Approximately 36 more were delivered partially completed.

Both the data percentage delivered and the delivery/generation times show a steady improvement over the period depicted in this table. Of special interest is the decrease in delivery time. The apparent increase in time after 20 September is due to a change in the IDR pickup (from the NDPT) procedure. At about that time, there was a decrease in the manning available to the Network Operations Control Area for around-the-clock coverage, and delays of 6 and 7 h between generation and pickup/delivery times became common. Actual generation times stabilized at approximately 4.8 h from station LOS. The delivered data percentages improved after 27 July due to those enhancements mentioned above.

¹ Extracted from the Prime Mission IDR Statistics Report generated by the NDPT.

A profile of the quality of the IDRs delivered, excluding remakes, is depicted by Fig. 3. This shows the percentage of IDRs that were delivered with missing data blocks. To illustrate, approximately 83.4 percent were delivered with five or less missing blocks. The actual percentage of the total delivered data is shown in Table 1 and Fig. 1. A different view of IDR quality is provided by Fig. 4. In Fig. 3, only orbital operations original IDRs were included (remakes and supplemental excluded). The percentage figure listed in the abscissa reflects a given delivery percentage, while the ordinate shows the percentage of all IDRs that met that criterion. For example, 84.3 percent of all IDRs contained 99.990 percent (or more) of the required data.

Figure 4 indicates that 60.6 percent of all IDRs were delivered without any missing data. The remaining 39.4 percent of IDRs saw one or more malfunctions occurring during the merge/recall operation, and those IDRs represent 100 percent of the data that were recoverable at the time of delivery. In some cases, the decision was made to release a less than 100 percent IDR to Project, so that the data could be processed.

Early in the orbital period, the decision was made to deliver IDRs with 99.8 percent or more of all required data logged by the stations. Then, Viking Data Records personnel established the guideline of requesting only remakes of IDR gaps of more than six blocks. These two decisions relieved much of the pressure from operating personnel in the Network Data Record Terminal, and the workload backlog became reduced to a more workable level.

III. Constraints

One of the major factors impacting IDR generation was the limited amount of time available for data recall. With only two wideband lines available, and three stations (64-m) engaged in around-the-clock support, there was not much time available for extended recalls.

Under normal conditions, with the Data Records Processor and Automatic Total Recall System (ATRS) interface working, there was sufficient time to meet all requirements and insure a high-percentage IDR. However, 5.88 percent of all IDRs (46) were one or more days late due to recall and/or playback problems resulting from hardware malfunctions at either end, high numbers of recallable gaps, systems interface problems, or tape "read" problems encountered after the station had been released.

The problem worsened when a large number of gaps were waiting recall from both the current pass and any backlog. When this occurred, the operational priorities required recall

of the current pass first, followed by the backlog. The capability of recalling multiple streams of data did exist, but a backlog (and the attendant pressures on NDPT personnel), coupled with the current day's requirements, made it difficult to verify that all recall tapes were complete and readable. One day's backlog could impact several days of normal IDR production until all the backlog was worked off.

IV. System Anomalies

There were several areas in which problems could impact the production of IDRs within the Viking delivery time requirements. These were the Network Data Log function, recall and gap editing function, and merge function.

A. Logging Function

The Network Log Processor provides the interface between the NDPT and the rest of the Network. All incoming and outgoing traffic is routed through it, to include interfaces between Building 230 (NDPT) and Building 202 (NDPT) (Fig. 1). In addition to routing all data, the NLP logs all inbound high-speed and wideband data plus the outbound messages to the Network. As the data are received by the NLP, they are logged on one of four Network Data Log (NDL) tapes: one for all high-speed inbound, one for each of two wideband lines, and one for outbound messages. Unfortunately, the NLP does not have the capability to validate that it writes tapes correctly, and improperly written data blocks/records are not detected until the merge function is carried out.

B. Recall Function

The recall portion of the Data Records Processor interfaces with the ATRS program in the station TCP (Fig. 1). Edited gap lists received from the Sigma 5 in the Network Control System are stored on the DRP disk. Full capacity is twelve streams of up to 199 gaps each. Recall can start only when the DRP has one or more streams available and the station TCP is initialized for ATRS recalls. Typical problems encountered with this arrangement were:

- (1) TCP not responding. The DRP recall initialization blocks were observed to leave Building 230, but the TCP did not acknowledge receipt. A variation of this problem occurred when the TCP acknowledged and then remained inactive. Resolution normally consisted of one or more reloads/recoveries of the ATRS program. This problem occurred frequently throughout the period of this report.
- (2) Initialization acknowledged, tape positioned, no data received. Usually the station Digital Original Data

Record (DODR) tapes appeared to be searching for data, but none were recovered at the Data Records Processor. Either the DODR tape started after the recall request, or the program required another reload/recovery.

- (3) Data blocks rejected. Sometimes the data received were outside the time range of the active recall request. Either the data contained a timing anomaly, or the TCP's high-speed status block was received prior to the last block of recall data transmitted. The latter problem was found to be due to the routing of the data streams. Normally the status block is transmitted on land lines, and the wideband data are relayed through a satellite. When the gaps are sufficiently close, the status block is received prior to the data due to the greater distance (and longer time) the wideband data have to travel. At the station, the sequence is as follows: when the data buffer is empty (recall data sent), a status block is transmitted to the Data Records Processor within a few microseconds after the data blocks.

Example:

17,700-km (11,000-mi) high-speed line for status blocks
72,400-km (45,000-mi) wideband line (via satellite) for data

$$\text{Circuit delay} = \frac{17,700 \text{ km (11,000 mi.)}}{299,300 \text{ km/s (186,000 mi/s)}} = 0.059 \text{ s for status blocks}$$

and

$$\frac{72,400 \text{ km (45,000 mi)}}{299,300 \text{ km/s (186,000 mi/s)}} = 0.242 \text{ s for data}$$

The difference of 0.183 s is greater than the computer times at either end, and the status block arrives prior to the data. When DRP receives the status block, that message is closed and a new one opened. The data then arrives and are rejected as being out of range of the new message.

The only operational fix was to have both data streams assigned to the same type of communications circuit. Recently, a software fix has been designed to provide the capability of writing the data to tape rather than rejecting them as was done previously.

- (4) Availability of edited recall messages. Any systems failure in the telemetry processor (TLM, RTM), the support system (NCS/Sigma), or the DRP software can cause the need for a reload of the system. This can delete the required gap files. The options available are

to either recreate the gap list by reading the NDLs back through the Test and Training System into the Telemetry System, or to do an "NDL only" merge and build a manual recall stream. Both actions are time-consuming and normally cause an IDR to be late.

- (5) Bad data lines. An excessive number of gaps or late receipt of edited Gap Lists from NOCA can also cause problems. When there are less than 200 gaps, the system normally works well. However, instances of over 700 gaps in a pass have occurred and saturated the system. Gap editing time requirements have exceeded the man and machine hours available for the task and have caused delays of 24 h or more in delivery times. A further complication is the slow rate at which the DRP prints out recall status messages (approximately 70 characters per second when 300 characters per second are required to keep up with system messages). This means that the initial validation of the recall has to await the machine printout and may lag the data by several minutes.

C. Merge Function

The merge processor is the first place the validity of the NDL and Recall tapes are checked. Until the merge summary prints out, or the system alarms over a read error, there is no way of ensuring that the data are recoverable. Under the original DRP software and tape controller, there was no way of knowing if the IDR was even valid until processed by the Viking Project. The introduction of the new tape handler software on 9 June 1976 remedied that but introduced new problems. Until the hardware tape controller was modified on 26 July 1976, the new software was halting several times during each IDR run and severely impacting generation times.

However, several anomalies continued to hinder the merge process:

- (1) System would not accept tape. The system refused to read NDL or merge tape because an apparent parity error had been detected by the tape handler. The operational workaround was to then mount a second NDL on a separate drive, reassign the drive address, and open the new tape. If that was unsuccessful, a series of NDL tapes were tried until one was accepted. Once the tape had been opened, the drive addresses were reset and the merge proceeded.
- (2) "Terminal" read errors. When the Merge program encountered a "terminal" read error, it closed out the IDR, wrote a summary, and terminated the run prior to the end of data. Originally, the corrective action was to put a new load point on the tape at the point of the read error. Then the tape would be mounted on a drive

assigned to the NLP, and a new tape header written there. The merge job would then, if the process worked, be started after the new load point. Unfortunately, this procedure did not prove very successful and caused large outages.

Currently the operational "fix" is to halt the tape when the terminal read error is detected; then, a new job is started using the false NDL option with reassigned tape addresses as in the problem covered in Paragraph C-1.

- (3) "End of Recall Data" errors. This condition arose when trying to merge multiple recall files from a single recall tape. The system would sense a false "end of data" condition and refuse to process the remainder of the recall data. In this case, the only recourse was to recall the data again.
- (4) System halts. System "halts" occurred on a random basis and only a system recovery/reload could restore operations. This condition required a "reinitialization" of the merge program with a further loss of time.
- (5) Data block "time tag" errors. Occasionally a data block would be received where the day, hour, or minute was outside the "window" of the IDR request. When this occurred, the system believed it had recovered all the available data and terminated the job. The only way to merge any data past the data record containing that block was to stop the tape at that record and use the tape address procedure mentioned for other tape problems. The merge then would be restarted using a start time of a few seconds after the error.

To ensure that the above problems did not cause Intermediate Data Records to be late, the merge function was started on a backup Display Computer as soon as the first recall tape became available. By doing this, the content of the recall tape and Network Data Log tapes could be validated, and any data losses due to any of the above listed anomalies could be made good. This procedure produced a high percentage of complete IDRs during orbital operations, as shown in the accompanying data.

V. Improvements

There are several design improvements in progress that are expected to have significant impact on IDR production performance. In order of their potential for improving performance, they are:

- (1) Redesign of the magnetic tape controller (hardware) and handler software.
- (2) Revision of the merge program to allow reading NDLs past tape records with "terminal" error.

- (3) Change to the recall processor software to allow data to be logged to the Recall tape after the status block is received.

VI. Conclusions

The Intermediate Data Record generation system has proven to be a viable means of supporting the Viking Project Data Records requirements. While there are still problems that need resolution, the combination of known operational workarounds and pending systems enhancements should minimize their effect.

Central to the successful generation of any IDR is the recall function. All the other anomalies can be dealt with, given time

to recall any missing data. But recall problems have a limited time frame in which to be resolved. It is the one function that ties everything together. As illustrated in Fig. 1, all other computer systems that handle the data to be merged have to interface correctly and in a timely manner for the recall function to work.

Because of the anomalies in the system, a real-time tradeoff has to be continually made as to when an IDR should be released. The guideline followed throughout most of the orbital operations period was to release any IDR that had over 99.80 percent of the committed data rather than delay for the next available recall periods. Gaps of excessive size (over 6 data blocks) were then marked for a "remake" at a later date.

Table 1. IDR performance

Time Period	No. of Passes	No. of Remarks	Avg. Percentage	Avg. Delivery Time, h	No. Late	% Late
20 June–20 July	84 ^a	5	99.966	10.93	10	11.9
20 Aug.	160	42	99.983	10.45	17	10.56
20 Sept.	192	10	99.996	4.867	6	3.1
20 Oct.	221	27	99.994	6.33 ^b	13	5.9
10 Nov.	125	18	99.997	4.89 ^b	0	0.0
Totals	782	102	99.990	7.07	46	5.88

^aTwo passes waived due to excessive gaps and recall problems.

^bTimes reflect change in “pickup” policy. Generation times average approximately 1 h less.

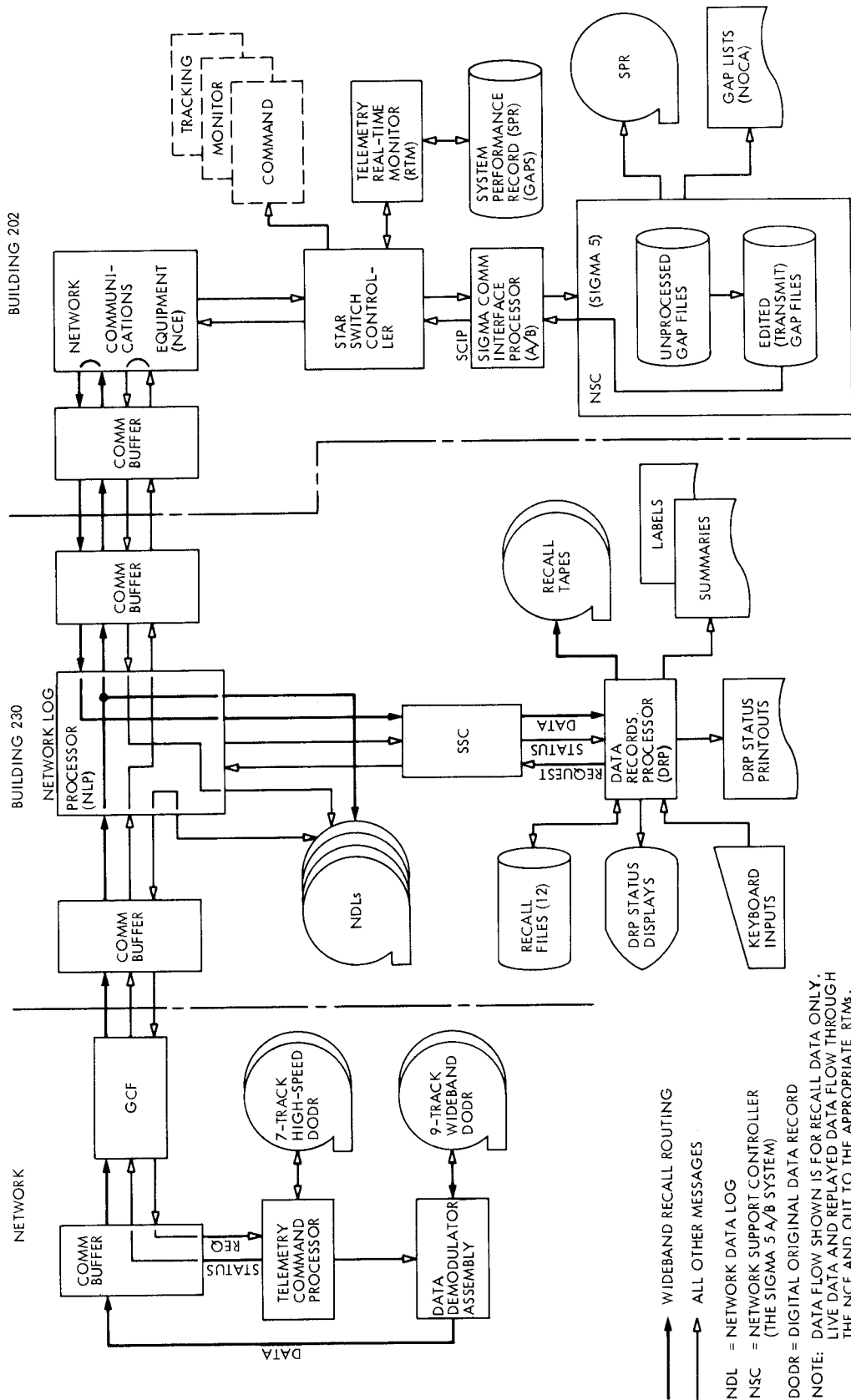


Fig. 1. Data flow paths for Intermediate Data Record production

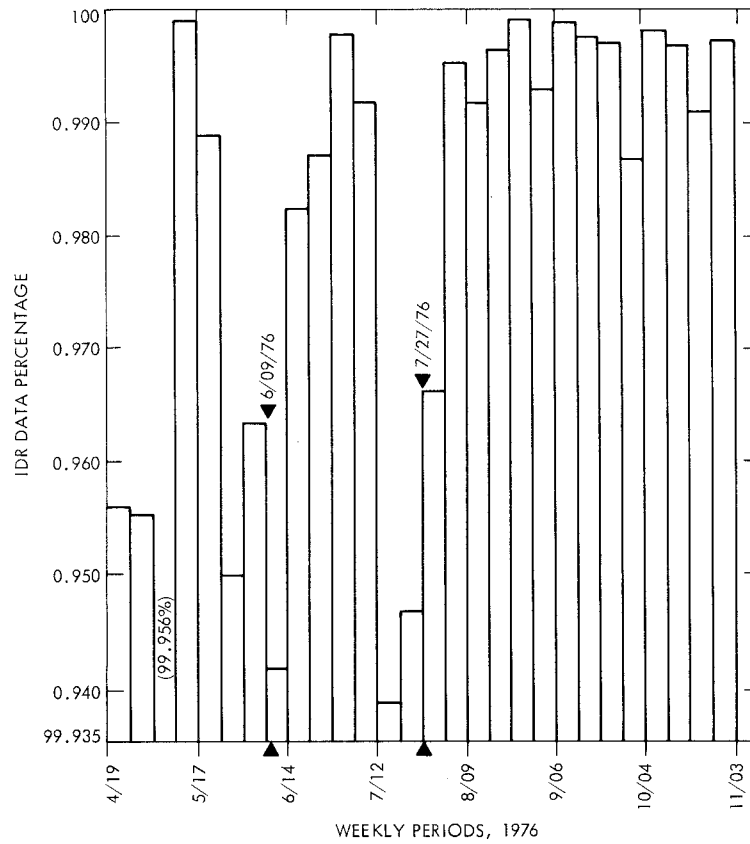


Fig. 2. Viking IDR weekly data percentage history

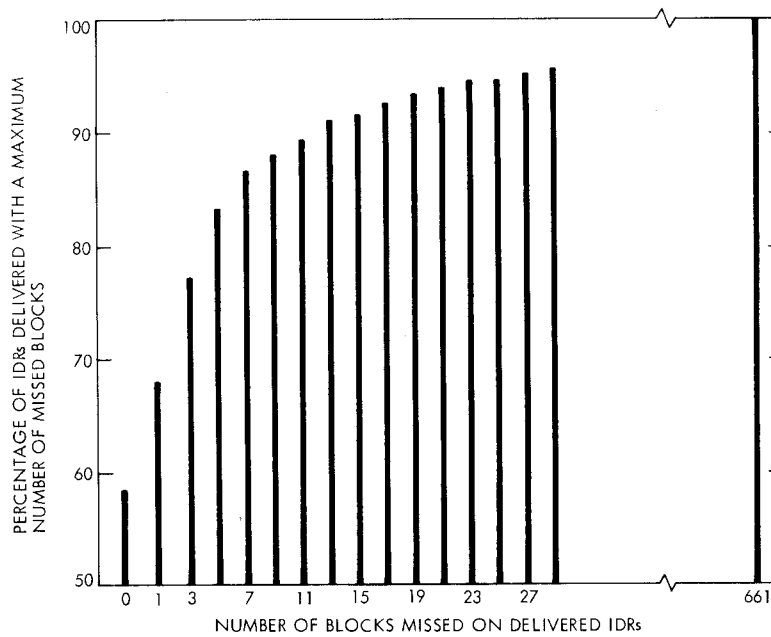


Fig. 3. IDR profile of actual missed blocks for all Viking Support

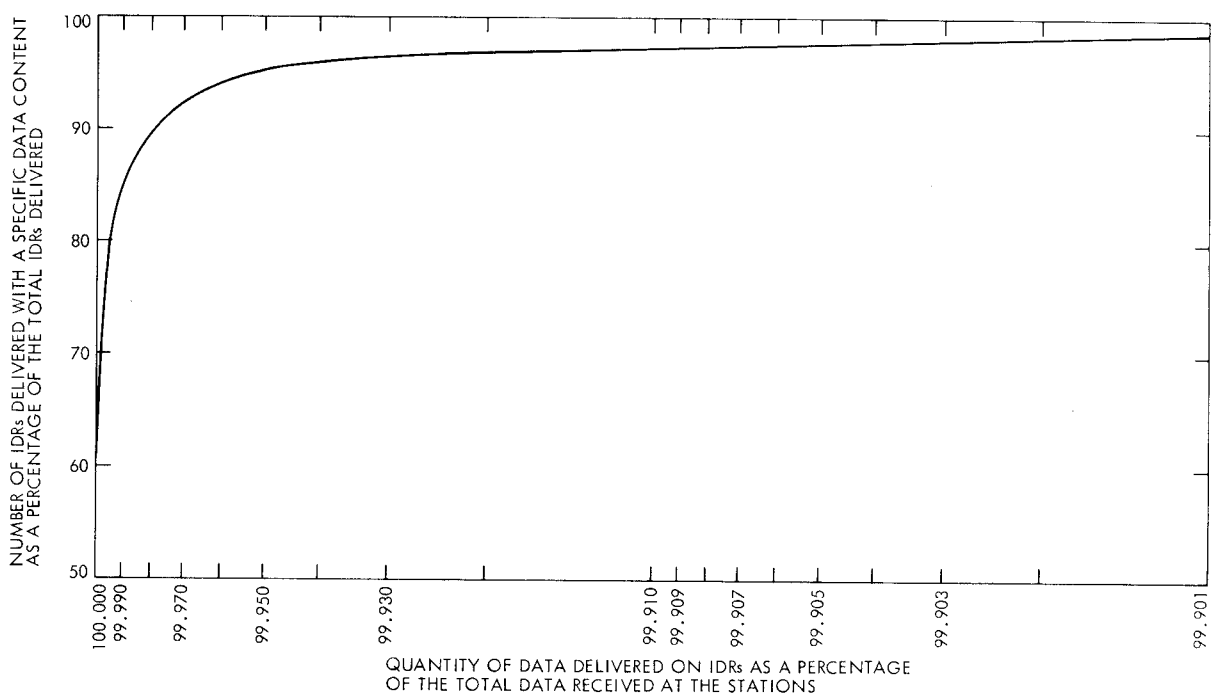


Fig. 4. IDR quantity profile for orbital operations